

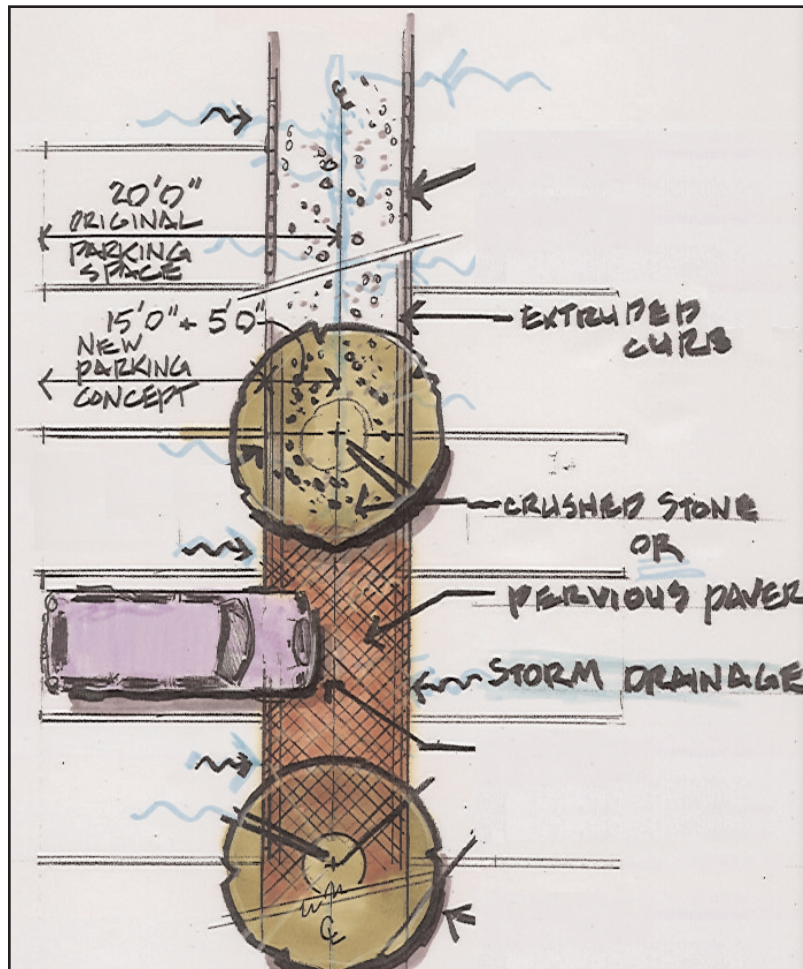
Appendix E

Example LID Measures

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Appendix E-1: Infiltration Divider



Description

A stone filled depressed infiltration strip accepting sheet flow from adjacent paving. Typically 3-4 feet deep and of variable width and length. Surfacing options include pavers, or $\frac{3}{4}$ inch stone (plain or ornamental). Trees and a strip of grooved pavement are recommended for delineation of the divider and in place of curbing.

Application

This is an infiltration device used to collect runoff from the parking space and travel aisle. It occupies the space usually reserved for vehicular overhang (front wheel to bumper) and is an efficient use of this normally paved and unutilized area. As the name divider implies, it is used to separate two rows of face-in parking and serves to break up the expanse of pavement with moderate sized trees.

Advantages

By using the overhang space in a parking lot the device does not compromise the number of parking spaces attainable at the site. The island can serve the same traffic routing function as raised parking islands. Impacts from foot traffic through the infiltration divider are minimal.

Cost is mainly affected by surface treatment. The plain stone surface treatment is not as costly and performs as well as the more expensive pavers which can be used by those who wish to add more distinction and aesthetic appeal to their parking lot.

Disadvantages

Planting choices may be limited by drought tolerance and width of island (shrubs may be too wide at the car bumper level and become deformed/injured).

The low organic content within the island unit may not provide optimal treatment of organic pollutants if it is located in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Design Considerations

Designs are optimized at 8-10 feet in width which is the normal distance between front axles of vehicles parked nose to nose. The divider handles runoff from the centerline of a typical 20 foot wide travel aisle and the 15 foot parking space. This width also protects trees and cars from butting up to each other. When used as a true divider to separate two rows of parking, widths should not be less than 6 feet.

Depths can vary, but the floor of the structure should be at least two feet from the seasonal high water table. Depths from the inlet surface elevation to the floor of the structure of 2 feet or less are only appropriate if infiltrating the first ½-inch of runoff.

A deeper surface depression can maximize the volume retained within the structure as no stone occupies this space and all of it can be used for retention. Curbing or wheel stops could be used in this application to prevent cars from entering the depression. In some cases, curbing would prevent an even distribution of water to the surface of the structure and the gaps between wheel stops may become blocked and glazed over from snow plowing operations. Alternately, grooves should be cut in the pavement 6" from the edge, around the perimeter of the structure. The grooves will provide a reasonable assurance that cars will come to a stop as they pull forward in the parking space and will provide no restriction for water entering the structure.

Surface treatment materials must be highly porous and durable. They can range from ¾ inch stone (ornamental or plain) to pervious pavers. Cost will play a large part in the choice of surface materials since pavers are more expensive than stone.

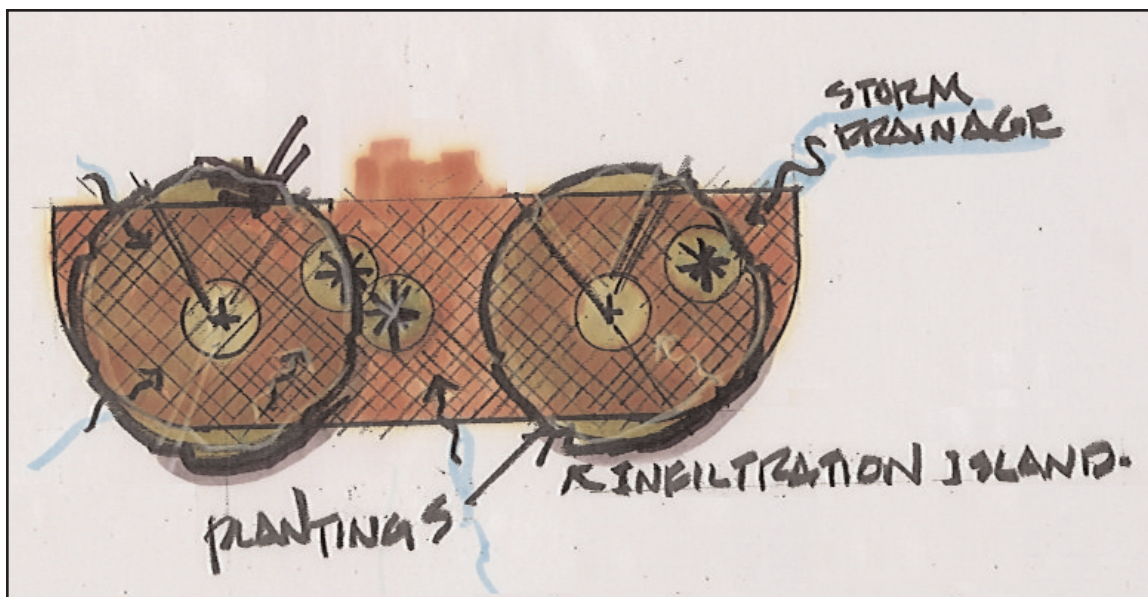
Treatment of stormwater in this device is accomplished by the stormwater passing first through the filter fabric and then through the native soil surrounding the main chamber. The main distinction of the Infiltration Divider is its ability to rapidly accept stormwater below grade. Organic material and the associated decomposition matter can hinder the ability of the surface to accept runoff.

Shade trees are recommended, to assist in delineating the Infiltration Divider from the traveled portions of the parking lot. This RPM offers a balance between rapid infiltration and aesthetic and traffic control objectives.

Maintenance

The frequency of surface rehabilitation can vary from 1-5+ years based on sand application rates and sweeping of the parking lot. Rehabilitation involves use of a vacuum truck or manual labor to remove the top 6 inches of material and replacement of the filter fabric pre-filter zone. Although stone may be screened from the accumulated sand and sediment and reused, it may be more practical and cost effective to send the removed material to a gravel facility for reprocessing and replace it with a new 6 inch stone layer after each cleaning.

Appendix E-2: Infiltration Islands



Description

A medium sized surface infiltration structure with a durable surface that can withstand occasional vehicle traffic. Plantings are sparse and infiltration capacity at the surface is high.

Application

These islands are meant to be used in parking lots at the end of parking rows or in areas where vehicles and pedestrians are likely to cut corners. The limited low-growing vegetation aids in providing sufficient line of sight for vehicular turning movements. Durable surface elements provide pedestrians space while waiting to cross from the parking lot to building entrance.

Advantages

Durable with the use of pavers so that it can withstand occasional traffic with little to no damage. Selection and variation of colors and style of pavers can help delineate parking for one store vs. another in a large parking lot.

Clear line of site for vehicle turning movements and pedestrian crossing.

With slight modifications to flatten side slopes, islands may provide additional adjacent space for access in and out of vehicles by handicapped persons.

Disadvantages

Planting choices may be limited by line of sight considerations and drought tolerance.

Pavers are more costly than a simple crushed stone surfacing.

Design Considerations

Although compaction of material is generally discouraged with RPMs, it may be warranted in the areas likely to be trafficked by vehicles.

If used at the downgradient end of a row of parking spaces and attached to another RPM such as the Infiltration Divider, the design should be graded such that each RPM provides the maximum amount of storage and infiltration. If both RPMs are sloped in one direction, placing one RPM downgradient from the other, the downgradient RPM could become overwhelmed with water, leading to frequent use of the overflow and underutilization of the available storage space in the upgradient structure.

The low organic content within the structure may not provide optimal treatment of organic pollutants if the structure is sited in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Maintenance

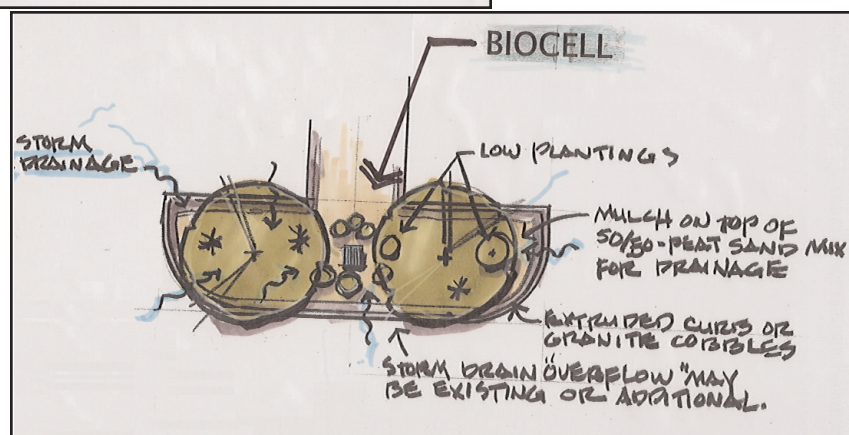
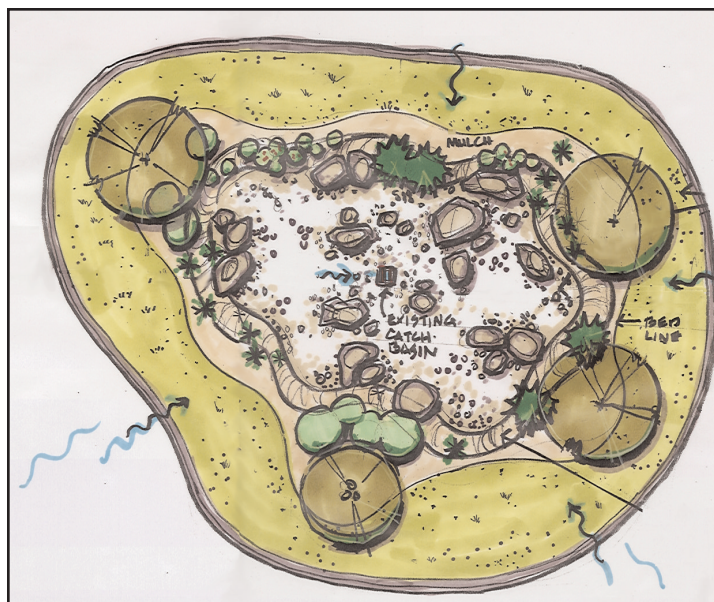
Paver surfaces located in traffic areas will require periodic inspection for deflection (raised or uneven surfaces) to ensure that they will not be pulled up during winter plowing activities. This is best inspected in the Fall, before snowfall. If deflection approaches half of the paver thickness, the affected paver(s) will need to be re-leveled flush to the others.

Sand deposits that have accumulated on the surface of the RPM will need to be removed periodically. A wet/dry vacuum is ideal for this and will prolong the life expectancy of the surface of the structure before the pavers, bedding material, and filter fabric must be completely removed and replaced and/or reassembled. The use of a push broom to remove deposits may be quicker in the short run, however may result in redistribution of much of the accumulated sediments and debris over the surface. If sediment removal maintenance is not conducted, the surface may require rehabilitation on a more frequent basis.

It is advisable to occasionally monitor the RPM during a rainstorm to determine if "preferential flow paths" have developed and/or if water seems to make its way to the overflow before using up the capacity of the reservoir/depression area. Forty-eight hours after the storm has stopped¹ the reservoir/depression area should have completely drained. Surface ponding conditions that exceed 48 hours are undesirable as nuisance conditions can develop soon thereafter. Prolonged surface ponding (over 48 hours) indicates that the surface area needs to be rehabilitated by removing and cleaning or replacing the surface material down to and including the first filter fabric barrier encountered. An observation well can be installed in the structure to determine whether the infiltration media below the filter fabric has clogged.

¹This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.

Appendix E-3: Bio-Islands & Bio-Cells



Description

An installation of varying proportions (Bio-Cell being small to medium in size and Bio-Island being a larger more centralized treatment and landscaping feature) that may be designed to support a wide variety of plantings and provides a beneficial "habitat" for pollutant removal.

Application

Other than scale, both Bio-RPMs may be used at a variety of sites. Their high organic component means that it can be used as a landscape focal point in a prominent location on the site, however infiltration rates may be compromised for the same reason. These systems (particularly the smaller Bio-cell) are better adapted to handling drainage from smaller, flatter, less "flashy" drainage areas.

Advantages

These systems provide a more complete habitat for beneficial microorganisms and thus excellent stormwater treatment can be expected. The high organic content and free form nature of the Bio-Island lends it to a wealth of colors and textures in the plantings. Separate planting zones within these structures can be created to support plants of complementing treatment efficiency and appearance.

Disadvantages

The trade off for having a higher organic content with greater planting choices is that the ability of the device to accept and quickly infiltrate water may be compromised.

Design Considerations

Care must be taken in estimating the proper storage volume within the reservoir area. Different blends of planting media (which occupy a substantial portion of the subsurface area) will yield considerably different available storage space.

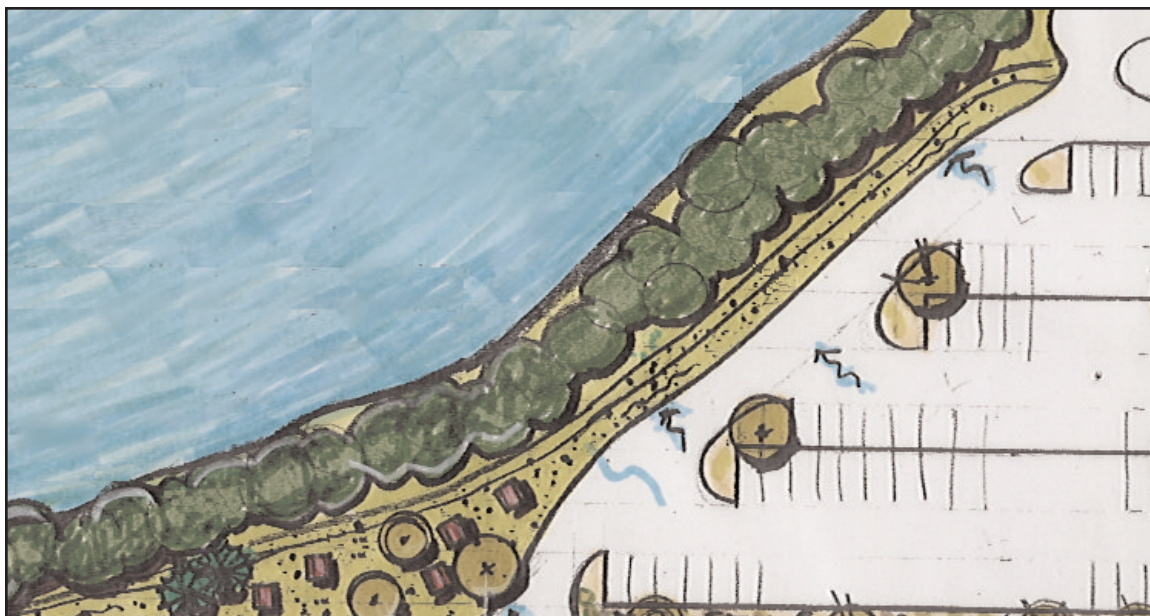
When bark mulch is used for the surfacing material, fresh mulch is preferable to aged for nutrient assimilation. If shredded wood chips are used as a substitute, hardwood varieties are known to be less likely to float when the structure has surface ponding.

In the larger Bio-Island application, designers should note that two treatment areas are intended. The outer layer is meant to settle out and assimilate reasonable amounts of sand and the coarse grass is meant to act as a living leaf/debris rack. This enables the inner area to receive water that is relatively free of debris and particulates, and thus preserves the surface infiltration rate and prolongs the time needed between clean up.

Maintenance

The leaves that fall onto the surface of these structures can quickly form a surface barrier to incoming water and so a Spring and Fall clean-up is recommended. The higher maintenance frequency in these structures relative to other RPMs is a function of their landscaping requirements. Owners want these structures well maintained to preserve and support their planting investment for a number of years.

Appendix E-4: Grassed Infiltration Strips



Description

A grassed area located at the edge of pavement to filter contaminants by flowing through vegetation and through infiltration. A typical strip size is 10 feet wide with a minimum depth of 6 inches to allow for temporary ponding of water. Grassed Infiltration Strips are aesthetically pleasing and perform a similar function to filter strips along a river.

Application

This infiltration device is used primarily for filtering overland stormwater flow from an impervious surface. It also incorporates infiltration into its treatment mechanism. It is ideally used when there is sufficient space around a parking lot or impervious drive.

Advantages

Grass is easily mowed and therefore is a low maintenance surfacing. The area used for this device is typically unused space around parking lots or along the edge of a road and can therefore easily conform to this treatment option. It has a sufficient storage capacity even though it is easily mistaken for a normal lawn. Occasional nonvehicular traffic is permitted by the surfacing.

Disadvantages

Infiltration rates through the planting media may not be as rapid as through other surfacing options. Should not be used in areas where perimeters of parking lots and drives slope towards the parking lot or drive, unless an overflow device is implemented.

Design Considerations

Parking lots and drives with perimeters sloping into them are not feasible for this device. Water must be able to flow across the device and away from the parking lot. Runoff flows with high concentrations of sediment will cause the depression to fill in. This will necessitate frequent maintenance for

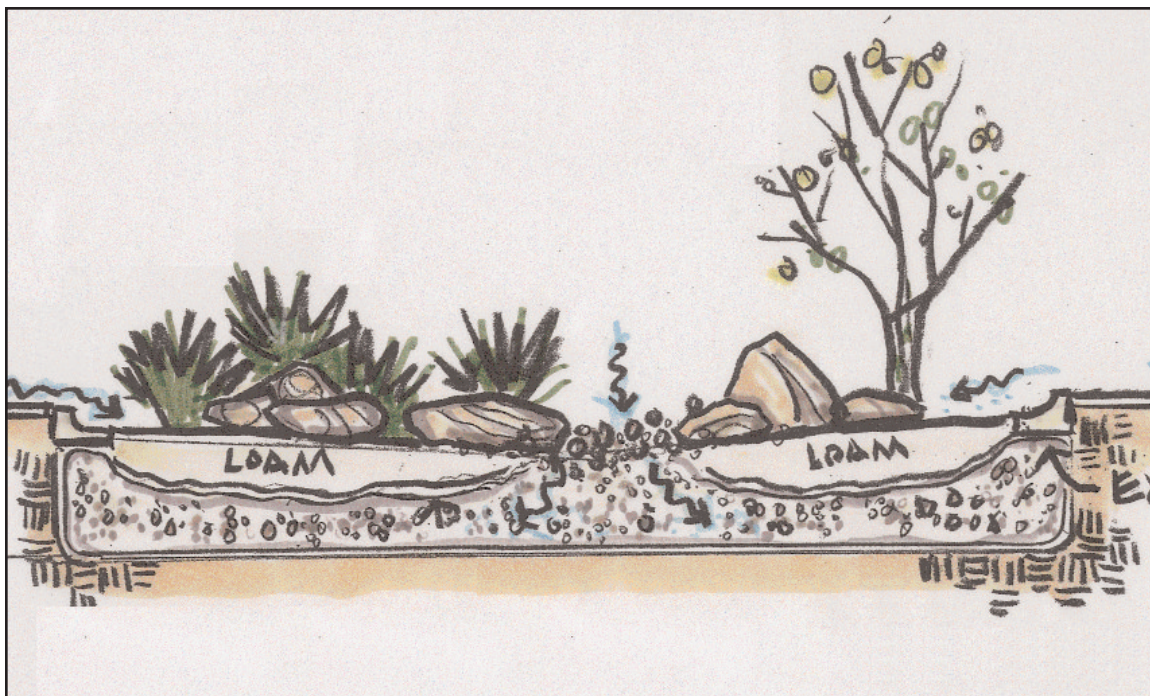
the strip and should be avoided. These strips should be located where they are not frequently crossed or a small walking bridge could be placed to allow crossing after periods of high rainfall. The downhill side of the crushed stone area should be a minimum of 6 feet from any steep slopes.

High traffic areas should be avoided because of compaction and the potential for water to pond in the depression. If many people were to walk over the strip, the infiltration capacity will be greatly reduced. This compaction could also kill the vegetation and destroy the overall treatment effectiveness of the RPM.

Maintenance

The grass is a low maintenance surface which should be maintained at typical height. Occasional high flows may carry a lot of sediment into the depression. Upon removal of this sediment care must be taken to not dig up the current vegetative layer. The 1 foot planting media filter layer and the filter fabric will prevent silt from entering the crushed stone. When infiltration rates are greatly reduced from this silt, the planting media may be removed along with the filter fabric and new materials put in place. Maintenance costs are relatively cheap until the filter layer is excavated.

Appendix E-5: Dry Stream Infiltration Bed



Description

A large structure designed to contain and infiltrate large volumes of stormwater. A dry riverbed theme has been chosen, and certain landscape elements added (boulders, etc.) to showcase what might otherwise be a large stark infiltration strip. Other elements such as ornamental bridges and picnic tables allow the area to be used as an informal outdoor lunch area during good weather.

Application

This RPM is intended to handle large volumes and rates of stormwater typical of a commercial parking lot. Providing a picnic area can make the installation have even greater utility on the typical tightly constrained office parking lot.

Advantages

This RPM has the ability to handle large volumes of stormwater. The "themeing" of the structure can allow it to be used as an amenity and add character which may differentiate the property from others. Perhaps a good selling point to prospective buyers.

Disadvantages

The limited use of vegetation will provide little shade or cooling effects to the parking lot as a whole. As a large centralized device, this structure provides a greater vehicle restriction. The abundance of ornamental features (such as boulders and picnic tables) can add cost with no gain in capacity.

Design Considerations

Volume calculations should account for ornamental features that are proposed to be located below the invert of the overflow.

When bark mulch is used for the surfacing material, fresh mulch is preferable to aged for nutrient assimilation. If shredded wood chips are used as a substitute, hardwood varieties are known to be less likely to float when the structure has surface ponding.

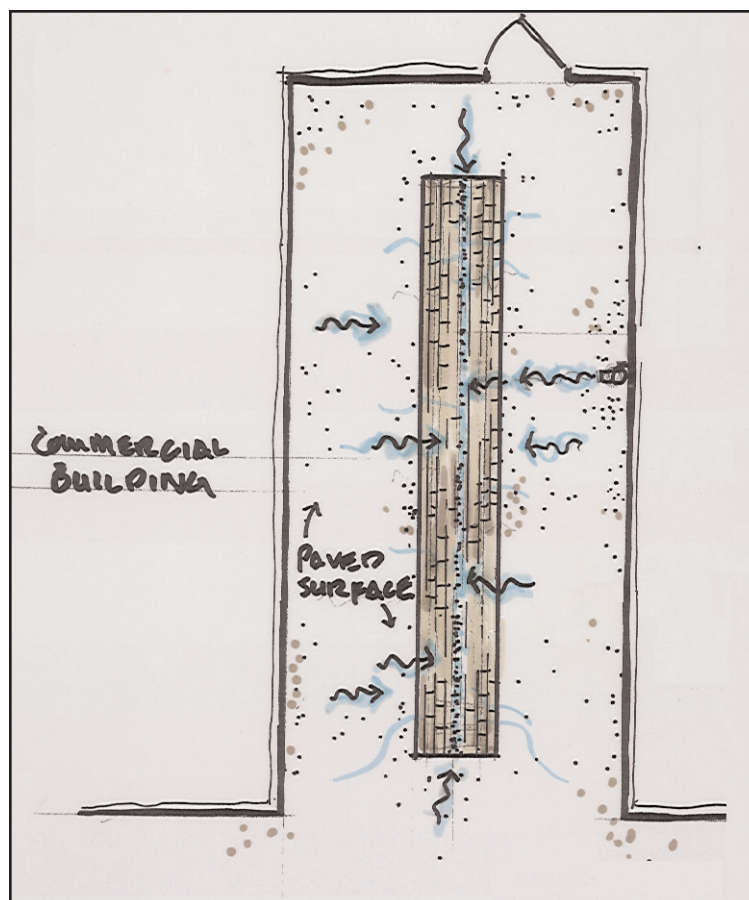
Because of its size, a significant slope throughout the length of the structure (when installed parallel to the slope) can cause ponding, and associated overflows at the downgradient end and underutilized storage volume at the upper end. Installing the structure perpendicular to the slope is the preferred orientation, but in cases where it must be installed parallel, impervious walls should be installed down to the floor of the leaching area. These barriers serve as grade checks and should extend through the surface (and perhaps hidden by a footbridge) with sufficient reveal to compartmentalize the structure so that lateral movement is minimized.

If picnic tables and other pedestrian attractive features are used, localized compaction may occur resulting in less stormwater infiltration in these areas. Stepping stone walkways or seating areas can be added and are one way to concentrate use within the structure. These impervious features should always be surrounded by pervious materials.

Maintenance

Because the mulched areas serve as pretreatment zones they must be managed as such. The mulched planting area will require periodic inspection for sediment buildup. Sediments collected in specific areas that are not retained by the planting bed will require periodic removal. The RPM should also be inspected occasionally during a storm event to ensure that the RPM is not short-circuiting (creating preferential flow paths for the runoff) which minimizes the pretreatment effects of the mulched planting area.

Appendix E-6: Alley Infiltration



Description

A surface infiltration area with a narrow entrance comprised of a durable surfacing such as cobble stones or pavers. No vegetation is used in this structure.

Application

Alley Infiltration is meant to be used in narrow areas where vehicular traffic is concentrated. Areas with roof leaders that discharge to a paved surface may also be served by these installations. Designers who wish to disconnect roof leaders from a current underground storm drain connection and allow them to discharge to a paved surface (for entrance into the Alley Infiltration) should consider safety issues that may arise in winter due to icing.

Advantages

At sites with little or no existing access to the underlying soil, these installations allow for stormwater infiltration with no loss in serviceability of the area.

Disadvantages

Surfacing the Alley Infiltration structure with a durable material such as pavers or cobblestones can comprise a significant portion of the cost of the installation.

Proximity to foundations may necessitate underdrains and/or installation of impervious barriers that may affect the level of groundwater recharge.

Design Considerations

If Alley Infiltration is used in service entrances, areas where heavy vehicles are likely to be turning and tracking across the pervious surface, or any other traffic patterns where the vehicles don't straddle the pervious surface, designers provide structural support (more compaction of subgrade and bedding materials) while maintaining sufficient surface infiltration rates.

If foundations or other subsurface structural features are located nearby (within 10') or downgradient of the Alley Infiltration, advice from a geotechnical engineer should be sought.

The low organic content within Alley Infiltration may not provide optimal treatment of organic pollutants if the structure is sited in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Maintenance

Paver/cobblestone surfaces located in traffic areas will require periodic inspection for deflection (raised or uneven surfaces) to ensure that they will not be pulled up during winter plowing activities. This is best inspected in the Fall, before snowfall. If deflection approaches half of the paver/cobblestone thickness, the affected paver(s)/cobblestone(s) will need to be re-leveled flush to the others.

Sand deposits that have accumulated on the surface of the RPM will need to be removed periodically. A wet/dry vacuum is ideal for this and will prolong the life expectancy of the surface of the structure before the pavers, bedding material, and filter fabric must be completely removed and replaced and/or reassembled. The use of a push broom to remove deposits may be quicker in the short run, however may result in redistribution of much of the accumulated sediments and debris over the surface. If sediment removal maintenance is not conducted, the surface may require rehabilitation on a more frequent basis.

Appendix E-7: Decorative Planters



Description

A self-contained upright structure that provides stormwater treatment and attenuation, but usually little groundwater recharge. With similarities to window box planters or raised planting beds, these designs are very ornamental.

Application

The Planters are designed to capture and treat stormwater originating from rooftops, by intercepting water from roof leaders prior to it entering an existing underground piped drainage system.

Advantages

For sidewalks and other areas with constricted spaces, the planters can be designed to be narrow, and yet still perform well and look attractive.

The generous volume of planting media used in these designs should allow for a wide variety of annuals to thrive.

Disadvantages

Planters are not designed to provide recharge to groundwater.

Because the Planters must be disconnected in Winter (downspouts must be disconnected from the planters and redirected to their original point of discharge), the volume of water treated annually is less than that of other RPMs that receive at least a portion of meltwater during freeze thaw conditions of late Fall and early Spring.

Design Considerations

Depending on space constraints, the planters can be tall and flush with a wall as might be the case with an installation on a sidewalk, or they can be shorter and wider making it similar to a raised planting bed.

Designers and owners should understand that during the Winter the Planters will be exposed to the elements and therefore may not be conducive to the survival of perennial flowers. For this reason, the beds will need to be planted annually, and thus annuals with their vibrant colors may be a good choice.

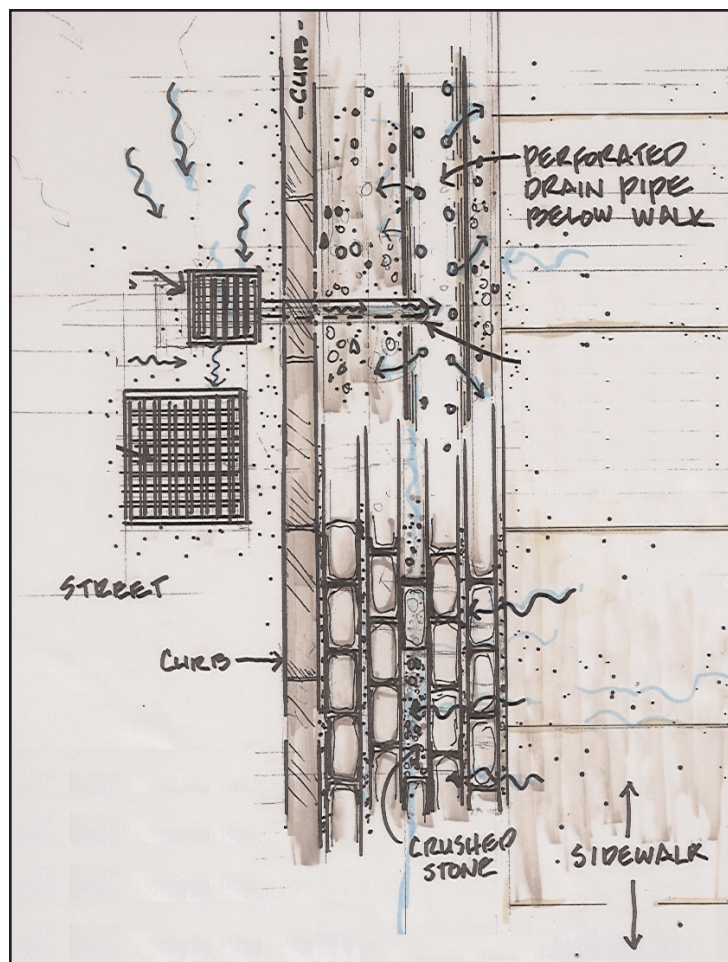
Weep holes should be provided at the lowest point in the structure to allow the system to drain between storms. The weeps could drain to the overflow pipe and thus back into an existing underground drainage system. This would be desirable if the planters are located on a sidewalk so that water does not flow across the sidewalk. If the planters are to be located on a pervious surface the weeps can drain directly to the ground, however foundation concerns (see discussion in Design Constraints Section) may need to be addressed.

Designers may want to install an access port on the side of the planters. This would allow access to the end of the perforated pipe for cleaning out debris and roots every couple of years.

Maintenance

Maintenance for the Planters is similar to that of normal flower beds, however the application of soluble fertilizer is discouraged. Those maintaining the plants and flowers should be careful not to overly compact the planting media and prevent percolation.

Appendix E-8: Curbside Treatment



Description

Curbside treatment has been developed to meet the stormwater management needs of downtown streets and sidewalks where pervious surfaces do not exist. The RPM involves the construction of a pervious sidewalk underlain by a perforated drain pipe. Runoff generated from the sidewalk can percolate through the pervious materials into the underdrain system, while runoff from the roadside can be collected in a catch basin and connected to the underdrain below ground. Normal difficulties relating to access for maintenance or replacement have been reduced in the design through the use of pretreatment devices and removable surfaces.

Application

Curbside treatment is meant to be used to treat runoff from sidewalks and curbed streets where few onsite options exist.

Advantages

Using cobblestones or pavers in place of concrete for sidewalks allows any runoff from the sidewalk to percolate into the ground. This treatment can add beauty and distinction to the streetscape. Most important from a maintenance/longevity standpoint, the removable (non-grouted) surface allows for easier access to the perforated pipe for cleaning or eventual replacement when it reaches the end of its service life.

Disadvantages

Pretreatment provided in the upgradient diversion catchbasin will not be as effective as most RPMs with pretreatment occurring at the surface and will be dependent upon frequency of catch basin cleaning operations.

Conflicts with underground utilities may limit the use of curbside treatment in some areas.

Design Considerations

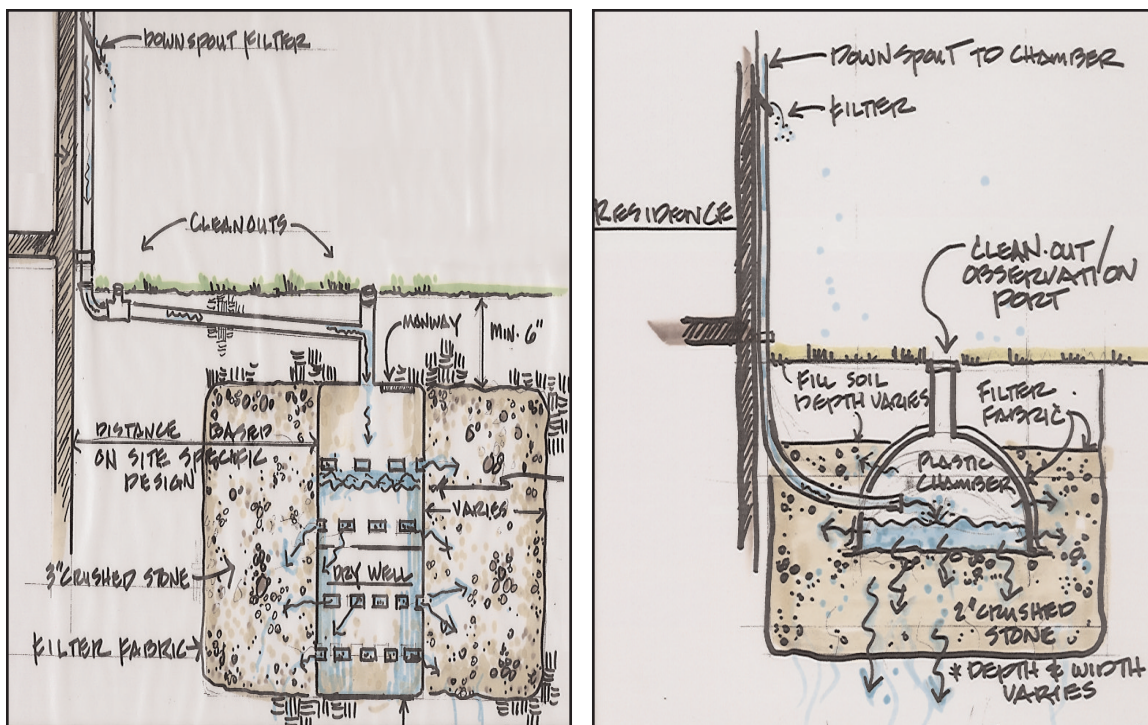
Pretreatment of the roadway runoff is provided in a new upstream catchbasin. To enhance the removal rate of particles, trash and floatables, a hooded outlet cover may be installed. The sump in the catchbasin should be as deep as is practical to further enhance settling.

A variety of pervious surfacing choices exist for use in this design since the runoff from most sidewalks can be captured and infiltrated sufficiently even with a brick (ungrouted) sidewalk. In areas where sidewalks are plowed, designers should confer with local personnel on this matter and utilize surfacing options that do not hinder these operations.

Maintenance

The long-term operation of Curbside Treatment relies heavily upon the removal of particles in the new upgradient diversion catchbasin. To this end, a commitment must be made to clean catchbasins before they are filled with sediment to the outlet invert. A good rule of thumb is to clean the catchbasin when the level of accumulated sediment is within 18" of the outlet invert.

Appendix E-9: Drywells



Description

Drywells are underground areas that have been excavated and filled with stone. The voids between the stone are where stormwater is stored until it can be leached to the underlying native soils. The greatest benefit of using drywells is to remove roof runoff from the flowstream, and to recharge groundwater. This preserves the capacity of other RPMs to address runoff from other sources that may contain higher pollutant loads.

Application

Drywells have been used for a variety of purposes, usually as a passive drain for foundations, or to receive periodic discharges from sump pumps. More recently, drywells have been used to accept roof runoff. The drywells presented here are mainly used to accept roof runoff, which typically is free of most material that would otherwise clog a system.

Sizes of drywells can range from small installations that handle under 100 gallons in small light-weight plastic chambers, to very large installations using preformed concrete leaching chambers.

Advantages

Drywells are simple structures that are typically inexpensive to install and with the variety of products available to construct them, many homeowners will find installation within their capabilities.

Drywells can be fully hidden from view. Because there are few above ground features, maintenance is minimal.

Drywells may be installed deep enough (below the frost line) that they would continue to infiltrate meltwater from roofs during the freeze thaw cycles that occur in late Fall and early Spring.

Disadvantages

Installations near foundations can cause leaky basements.

Design Considerations

Drywells have been historically used to capture water from one area and disperse it over another, however the drywells presented in this manual have a number of features that address weaknesses inherent in some of the past designs.

The improved drywells presented in this document utilize filter fabric to preserve the capacity of the leaching structure and stone reservoir. Early drywells were just stone filled pits with no protection against slumping and migration of the surrounding soil into the void spaces. A gradual reduction in capacity resulted. Small sinkholes or areas where the earth has settled are usually an indication that the drywell has failed. The use of non-woven filter fabric to completely encapsulate the stone reservoir area will prevent both of these conditions. The common practice of using straw as a pervious separation barrier is discouraged since over time it can consolidate and form a semi-pervious layer.

Cleanouts should be installed wherever acute bends in the pipe occur. One cleanout/observation port should be provided directly into the main leaching area so that the interior can be inspected without disturbing the ground surface over the Drywell. This port can be designed to serve as an overflow for large storms, so that once the capacity of the drywell has been used up water will just overflow to the ground.

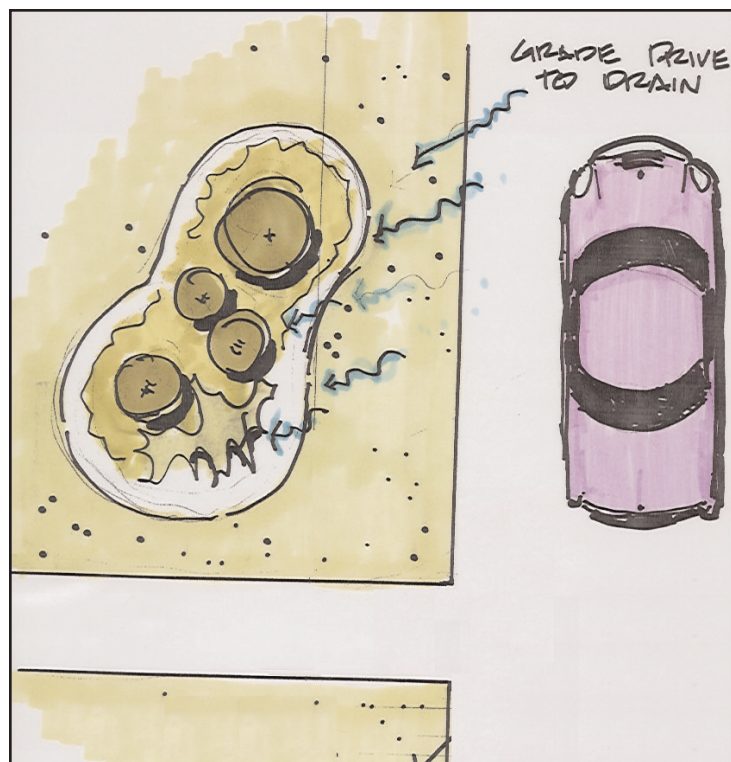
Because leaves could quickly "seal" off the interior of a drywell, some form of gutter screen should be installed for all gutters contributing stormwater to the drywell.

Maintenance

Maintenance for drywells is mainly preventative. Gutter screens should be cleaned as needed and drywells should be inspected through the observation port occasionally to ensure that they are draining completely within 3 days of the end of a storm.

In larger Drywells, manways are usually a standard component in the concrete leaching chamber. The location of these manways should be noted on plans or as-builts so that once buried, they can be found later and used to provide access for cleaning the inside of the structure.

Appendix E-10: Pocket Raingarden



Description

A small surface fed infiltration device used to decorate driveway entrances and receive driveway runoff. Pocket Raingardens are modeled after planting beds commonly found in residential settings.

Application

Although Pocket Raingardens can be used on larger commercial properties, they are best suited to residential application. On a commercial property the amount and rate of runoff generated on these substantial impervious areas would quickly overwhelm them, and so other RPMs are usually chosen for their higher infiltrative surfaces. On a residential property, a number of Pocket Raingardens are typically installed on a site for proper landscaping balance and due to their small size and capacity.

Advantages

The generous volume of planting media used in these designs should allow for a wide variety of plants and shrubs to survive. The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

Disadvantages

The relatively thick layer of planting media that supports plant growth will tend to have a lower infiltration rate than other more porous surfacing options such as stone. This is generally not a problem for residential applications if the contributing drainage area is not excessive.

Design Considerations

Designers and installers of Pocket Raingardens should be careful not to let the surface ponding depth exceed 8 inches, or let the water stay on the surface for more than 48 hours as nuisance conditions

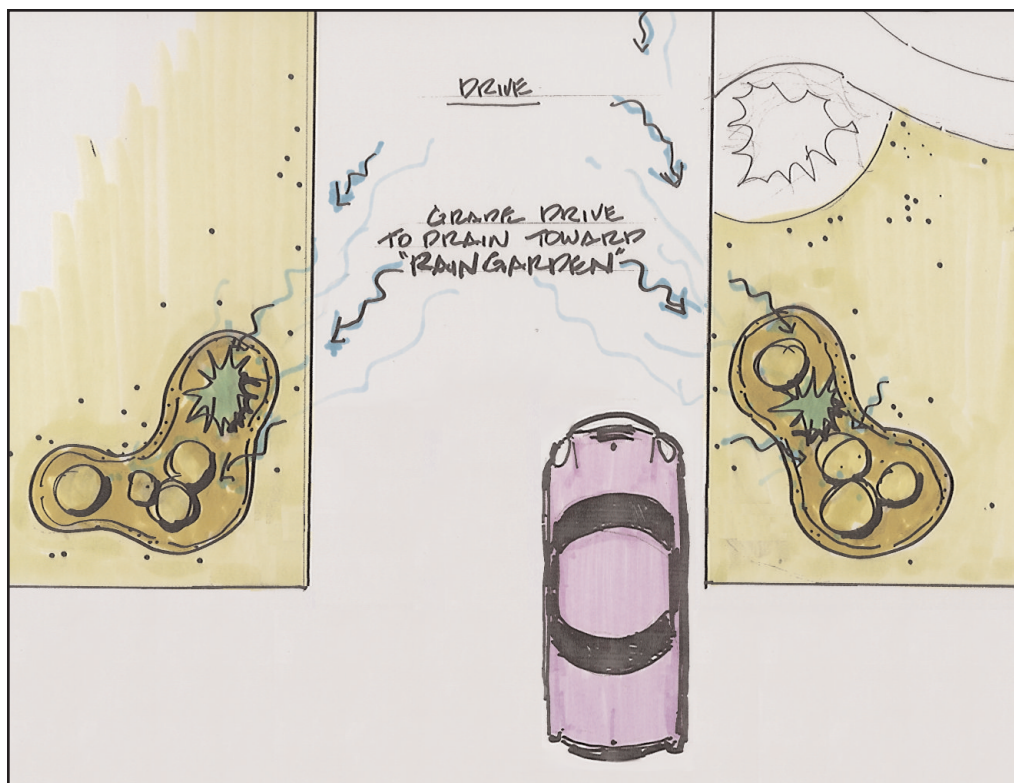
can develop in 3 to 4 days. The installation of an underdrain may be helpful in promoting shorter drain times if these conditions are anticipated and cannot be avoided. Remember however, that true groundwater recharge will not be provided if the underdrain discharges to a nearby municipal storm drain.

To aid in the degradation of certain NPS pollutants such as nitrogen, designers may want to consider adding an impervious liner under the leaching area of a Pocket Raingarden (if an underdrain is also provided). The liner should be placed 8-18" inches below the invert of the underdrain pipe so that water that pools in this pocket stays there for a sufficient time to become anoxic and promote denitrification. Underdrain discharge points should be located far enough away from living areas so that the "earthy" smell that sometimes develops under these conditions does not bother the homeowners.

Maintenance

The Pocket Raingarden is vulnerable to compaction and homeowners need to be aware of this when performing the simple maintenance that this RPM requires. Because all stormwater must pass through the thick layer of planting media, compaction within it will limit its overall capacity and can increase the period of time that water is ponded on its surface. To lessen compaction associated with foot traffic or maintenance activities, a bark mulch surfacing over the planting media is recommended. Additionally, homeowners should be discouraged from using fungicides or other persistent pesticides in or around Pocket Raingardens because, in addition to killing the undesirable targets, other organisms that aerate the soil (worms, ants etc.) may be killed. If this principle of preserving the infiltration rate is observed, the maintenance of a Pocket Raingarden is no different from any other conventional planting bed.

Appendix E-11: Raingarden Planter



Description

A small surface fed infiltration device used to decorate driveway entrances and receive driveway runoff. Raingarden Planters are similar to conventional planting beds found in residential settings, however they have a crushed stone edging along their downgradient side which serves as a conduit to the stone infiltration reservoir, once the organic planting media has become saturated.

Application

Raingarden Planters can be used on commercial or residential properties. A number of Raingarden Planters are typically installed on a site for proper landscaping balance and due to their smaller size and capacity.

Advantages

The depth of planting media used in these designs should allow for a wide variety of plants and shrubs to survive.

The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

The lack of filter fabric over the surface of the planting area makes cleaning easier since care is not needed to prevent tearing of the filter fabric.

Disadvantages

Because there is no filter fabric pre-filter in the planting design, more material within the structure may require removal to ensure all of the clogging media has been removed.

Design Considerations

Raingarden Planters do not utilize a filter fabric pre-filter which means that the structure's overall design life will be shorter, however the frequency of and type of maintenance will be far less than other stormwater treatment devices, and mainly involve replacing the mulch.

Designers and installers of Raingarden Planters should be careful not to let the water stay on the surface for more than 48 hours after a rain event¹ as nuisance conditions can develop in 3 to 4 days.

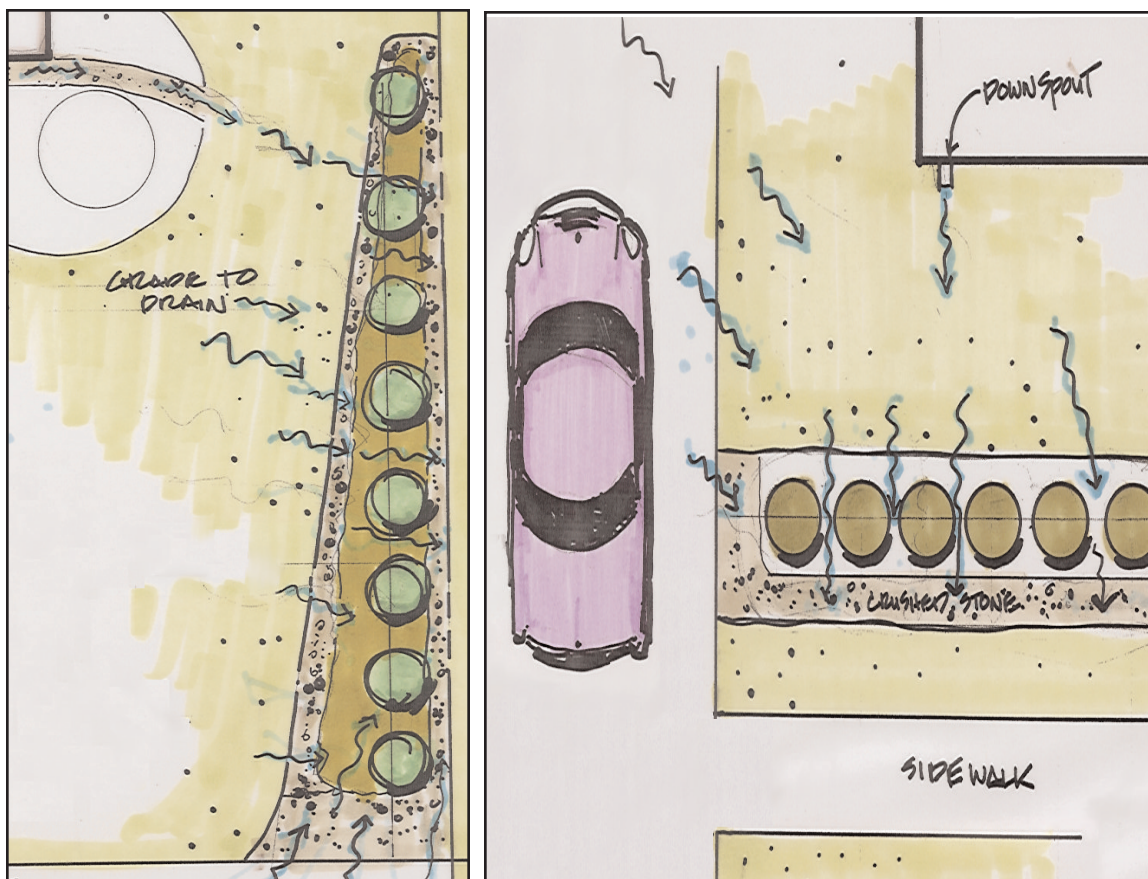
Maintenance

The Raingarden Planter is vulnerable to compaction and so homeowners need to be aware of this when performing the simple maintenance that this RPM requires. Maintenance will involve the periodic removal of sediments from the surface. The duration for the system to drain can be used as an indicator of when the system has clogged.

Homeowners should be discouraged from using fungicides or other persistent pesticides in or around Raingarden Planters because, in addition to killing the undesirable targets, other organisms that aerate the soil (worms, ants etc.) may be killed.

¹This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.

Appendix E-12: Raingarden Strip



Description

A Raingarden strip is a redesigned hedgerow or garden border that has an enhanced ability to intercept and infiltrate stormwater runoff from residential streets, driveways and sheet flow from adjacent lawn areas, if needed.

Application

Raingarden strips can be used in either a commercial or residential setting with the appropriate modifications to the scale of the structure.

Because of the linear shape of these designs, locating them downgradient of other smaller RPMs can provide a backup or duplicity of treatment on sites where this is desirable. For instance, if because of space constraints, an undersized drywell is installed, it may overflow during moderate storms. The excess water may then flow across a lawn picking up fertilizer residues and other NPS pollutants. These would be captured however, by the Raingarden strip that is located downgradient at the edge of the lawn.

Advantages

The generous volume of planting media used in these designs should allow for a wide variety of plants and shrubs to survive.

The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

Disadvantages

The appearance and orientation of this RPM may limit its landscaping appeal as people have different landscaping taste and needs. These RPMs are intended to be located in close proximity to a driveway or street and may look awkward placed in the middle of a lawn.

Design Considerations

When located to receive runoff from streets or large driveways some stabilized surface is needed where the stormwater enters the Raingarden Strip. This can be stone or some other durable material that is not likely to be moved by the force of the water entering the Strip in this concentrated location.

Care must be taken when designing the Raingarden Strip to ensure that the planting media is not so isolated from the incoming flow that only large storms that fill the structure are able to moisten the planting media and roots. This is obviously less of a concern if drought tolerant plantings have been selected. For installations where sheet flow will comprise a major portion of the contributing stormwater, the planting media should extend to the upgradient edge of the Strip with the stone on the downgradient side. This lets the stormwater contact the media first and when it can no longer absorb moisture the flow continues across to the stone surface that provides a conduit to the stone reservoir area underneath.

Maintenance

If a stabilized entrance is provided, maintenance activities will include removal of surficial sediment deposits and replacing/raking stone that has been moved during large storms.

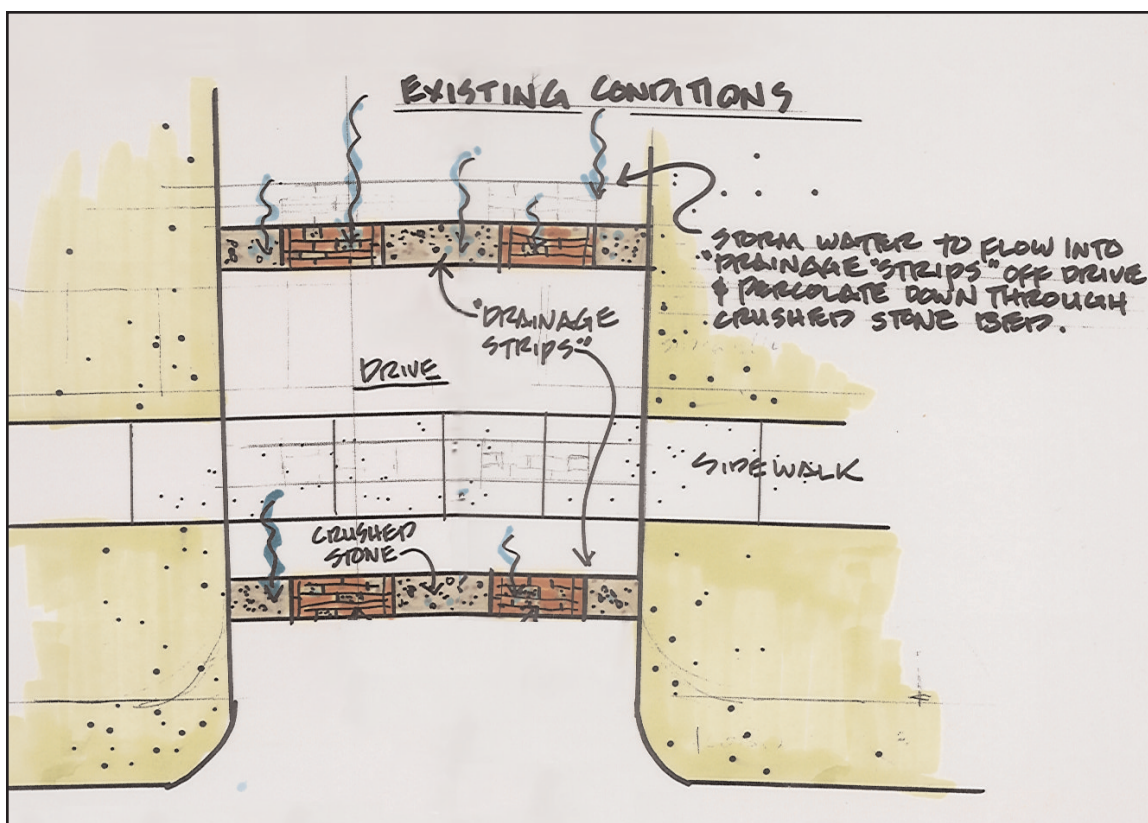
The bark mulch that covers the planting media should be replaced as needed.

If stormwater ponds on the surface of the structure for longer than 48 hours after the end of a storm¹, the filter fabric pre-filter may be clogged. In this case, the filter fabric and material covering the upper most layer of filter fabric should be removed. Owners may then either replace both the filter fabric and the cover material or, alternatively, clean the clogging material from them and reuse them. This material should not need to be disposed of at a landfill, however it should not be placed on an area that will be subject to runoff which might resuspend it.

The frequency of this rehabilitation will depend on the ratio of filter fabric surface to contributing drainage area, the amount of sand applied to the impervious drainage area, and the frequency with which preventative maintenance has been performed.

¹This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.

Appendix E-13: Driveway Drainage Strip



Description

This consists of an infiltration trench located in a driveway, and oriented perpendicular to the direction of travel. This RPM may be driven on and accepts stormwater runoff from driveways with low volumes of traffic (such as residential).

Application

This RPM is suited to residential drives or those with very low volumes of traffic with uniform vehicle types.

Advantages

These RPMs are very inexpensive to construct and can be used to delineate parking from travel areas or add some definition between shared drives.

Disadvantages

If the driveway is plowed in the winter, the operator should be made aware of the Strip so that they do not disrupt the surfacing materials.

Design Considerations

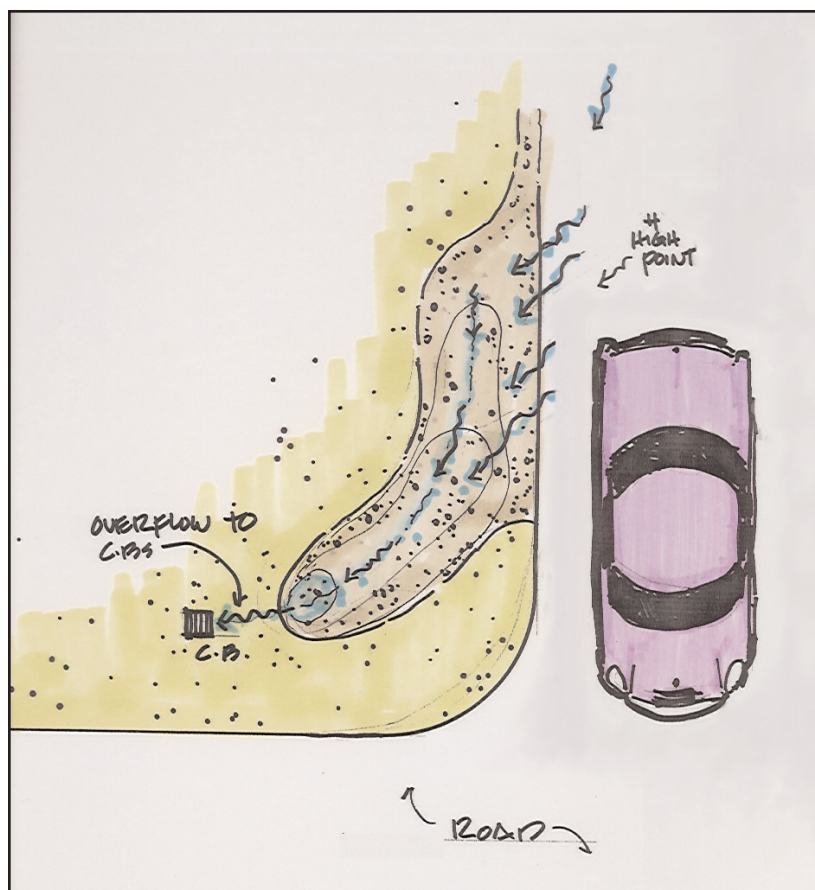
In driveways where there is a high degree of crown or cross-slope, a Driveway Drainage Strip may subject the adjacent pavement to abuse from plows. As with most plowing obstacles, prior scouting of the site (before it snows) by the plow operator and sufficient markings (reflectors or similar object) can alleviate most potential problems.

Maintenance

When stormwater no longer collects and infiltrates in the Strip or sediment can be seen occupying the void space of the stone, the stone and sediment must be removed and replaced.

If the pavers or other tracking material is protruding by more than half of its thickness, the bedding material should be re-leveled and the pavers re-laid to create a level surface with the surrounding pavers and pavement.

Appendix E-14: Containment Swale



Description

A shallow depression located adjacent to a roadway shoulder that is used to capture and infiltrate roadway runoff and/or lawn runoff before it enters a catchbasin. Although similar to a typical swale, this RPM is designed to pond and infiltrate water to the maximum extent possible, rather than as a means of conveyance. Excess water overflows into a nearby catch basin.

Application

There are two applications for this design. The first would be to collect roadway runoff from a street without an existing curb and gutter system. The RPM is constructed along the edge of the street allowing runoff to enter into it before discharging to a downgradient catch basin. The second application is to collect runoff from lawn areas that would normally flow into the roadway. The RPM could be installed between the lawn area and roadway. When the unit fills with water, it would overflow back into the street drainage system (as if the RPM had not been there).

Advantages

Roadside Stormwater Diverters are relatively inexpensive given the large amount of water that can be captured, treated, and recharged.

Disadvantages

Some road agents may be resistant to infiltrating water adjacent to a road's subgrade for fear of frost damage.

Design Considerations

Shoulder slopes should be maintained particularly in areas where the roadway is narrow and around corners.

Using an impervious barrier to shield a road's subgrade may be necessary to ameliorate concerns of frost heaves damaging pavement.

Maintenance

Sediment and accumulated debris should be removed in the Spring and late Fall after the leaves have dropped.

If stormwater ponds on the surface of the structure for longer than 48 hours after the end of a storm¹, the filter fabric pre-filter may be clogged. In this case, the filter fabric and material covering the upper most layer of filter fabric should be removed. Owners may then either replace both the filter fabric and the cover material or, alternatively, clean the clogging material from them. This material should not need to be disposed of at a landfill, however it should not be placed on an area that will be subject to runoff which might resuspend it.

The frequency of this rehabilitation will depend on the ratio of filter fabric surface to contributing drainage area, the amount of sand applied to the impervious drainage area, and the frequency with which preventative maintenance has been performed.

The Diverter should be inspected occasionally to make sure erosion is not occurring on any of its surfaces.

¹This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.